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(54) Title of the Invention : Insulating Heat Resistant Composite Porous Ceramic Metal Material

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Description

1. Title of the Invention : Insulating Heat Resistant Composite Porous Ceramic Metal Material

2. Scope of the Patent Application

Claim 1.

Insulating heat resistant composite porous ceramic metal material in which the metal is filled into the pores of the ceramic porous body.

3. Detailed Explanation of the Invention

[Field of Utilization in Industry]

This invention relates to the insulating heat resistant composite porous ceramic metal material.

[Existing Technology and the Problem That this Invention Intends to Solve]

In recent years, accompanying the installation of turbo chargers or super chargers, or due to low capacity high power engines, the heat load on the pistons has been increasing in both gasoline engines and diesel engines. Accompanying this, countermeasures for the wearing of the piston ring grooves, die wear, and the heat resistance of the crown part have been becoming necessary.

In the case of aluminum alloy pistons, as the measure to improve the wear resistance of the piston ring grooves and to improve the heat resistance of the crown part, cathodic oxidation treatment has been applied until now, and recently, the usage of aluminum composite materials in which silicon carbide whiskers are dispersed, has been suggested.

However, the former method does not exhibit sufficient heat resistance although it is effective for the wear resistance, and the later method has a cost problem since silicon carbide whiskers are very expensive. The wear of the piston ring grooves is promoted since that area becomes very hot, therefore, the wear resistance improves when the combustion heat at the top is insulated.

Considering the above mentioned points, the objective of this invention is to offer the composite material which has excellent heat resistance and excellent heat insulation, and which can be suitably used for the pistons of engines, at low cost.

[Method to Solve the Problem]

This invention relates to the insulating heat resistant composite porous ceramic metal material in which metal is filled into the pores of the ceramic porous body.

[Action]

Since it is a composite material of a ceramic porous body with excellent heat insulation and excellent heat resistance, and metal, this material exhibits excellent heat insulation and heat resistance. In addition, in the case of using it for pistons, both can become a single body in the form where the metal of the metal piston is filled as the metal phase into the interconnecting pores of a ceramic porous body, therefore, the bonding strength of the ceramic and the metal is large.

[Actual Example]

Next, the case where the composite material of this invention is applied to the pistons of an engine will be explained, but this invention will not be limited to this, and for instance, it can be utilized for the cylinders, cylinder heads, rocker arms, etc. as well.

Figure 1 is a cross section that shows an actual example of the piston of this invention.

In Figure 1, (1) is the piston body, (2) is its crown part, (3) is the ring groove part, (4) is the skirt part, (5) is the piston pin boss, and (6) is the piston pin hole. Several ring- like grooves are provided in the ring groove part (3), and the piston rings such as the compression ring, the oil ring, etc., are installed in these grooves.

The main body (1) is made out of a metal such as an aluminum alloy, etc. Except for the outer circumference area, the crown part (2) is made out of the porous ceramic body (10), and the metal of the main body (1) is filled into the pores (11) of the porous body (10), and the porous body (10) and the main body (1) are composited to become one body.

The larger the thickness of the ceramic porous body (10) that is composited with the metal is, the better the heat insulation becomes, however, it can be selected to match the required insulation level considering the shape of the piston or the material of the porous ceramic body, etc. Normally, a thickness of 5 mm or larger is preferred. When the thickness of the porous body (10) is less than 5 mm, the heat insulation is not

sufficient, and as the result, the heat resistance of the entire crown part decreases.

The above mentioned piston can be produced as follows.

First, the ceramic porous body (10) is produced.

This can be produced by the slip casting forming method, and for instance it can be produced by the following description, but it is not limited to this.

The slip casting forming method for ceramics is such that a sludge made out of the ceramic raw material, binders and media such as water, is poured into an absorbable forming mold such as a gypsum mold which lets the water be absorbed into the mold to obtain the desired formed body.

As can be seen in Figure 2, an organic interconnecting porous body (23), which can be removed by decomposition by heating later, is put in the mold (20) which is comprised of the bottom plate (21) and the outer frame (22) made out of gypsum, and the sludge (24) is poured from the top. At this time, the mold may also be of the closed shape and the sludge (24) may be injected under pressure too. Then, the sludge enters into the interconnecting pores of the organic interconnecting porous body (23), and the water is absorbed by the gypsum mold.

After the water is absorbed, the outer frame is released, and the formed body which becomes one body with the porous body (23) is taken out, and it is heated at a low temperature (for instance 450 ~ 600 °C) to decompose- remove the porous body (23), and thereafter, it is baked at high temperature, or it can be directly baked and the decomposition- removal of porous body (23) and the sintering can be done at the same time. Thus, the ceramic porous body (10) that can be seen in Figure 3 can be obtained.

The organic interconnecting porous body (23) is not particularly limited as long as it can

be decomposed and removed by heating, and resin foam, especially a poly urethane foam body is preferably used since it can be easily decomposed and removed at a low temperature of around 500 °C.

Next, as can be seen in Figure 4, the ceramic porous body (10) is put into the forming mold (30) that is comprised of the outer mold (31) and the inner mold (32), and molten metal is cast. Namely, the molten metal (35) of an aluminum alloy that becomes the piston main body (1) is poured between the outer mold (31) and the inner mold (32), and it is compressed by the press (34) via the ring (33), and thus, the molten metal (35) is filled into the empty pores (11) of the porous body (10), and after it is cooled, it is taken out from the mold (30).

Thus, the piston shown in Figure 1 can be obtained.

The ceramic raw material can be appropriately selected from various oxides such as alumina, silica, zirconia, etc., nitrides such as silicon nitride, borides such as zirconium boride, and carbides such as silicon carbide, etc., and for the preparation of the sludge, the existing binders and dispersion agents can be used.

Concerning the ceramic raw material that is used in this invention, a mixture of the above mentioned oxide type raw material and the non- oxide type raw material is preferably used for the reduction of the cost of raw materials, easy sintering, strength of the porous body and also for the improvement of the high temperature strength of the composite material. Especially, a mixture of an oxide type raw material such as alumina, silica, zirconia, etc., and a so called engineering ceramic raw material such as silicon nitride, silicon carbide, Sialon, etc., is advantageous from both the cost and strength standpoints. The proportions of the oxide type raw material and the non-oxide type raw material to be used should be preferably 70 ~ 95 : 5 ~ 30 as the weight ratio.

If the void ratio (volume %) of the ceramic porous body (10) is too low, the amount of

metal that enters into the pores will be too small, and if the void ratio is too high, the amount of ceramic will be too small, and in both cases it is not possible to attain a good composite effect. From this view point, the void ratio of the ceramic porous body (10) should be preferably in the range of 50 ~ 98 %.

Also, from the standpoint of giving sufficient strength to both the ceramic skeleton structure in the ceramic porous body (10) and to the skeleton structure of the metal that is formed by entering into the pores, the average pore diameter of the interconnecting pores (11) in the porous body (10) should be preferably 0.01 ~ 5 mm.

Normally, an aluminum alloy is used as the metal for the piston main body (1), however, copper or iron may be used too.

In the above description, the case of compositing the crown part of the piston was described, however, the piston ring groove part may be composited too.

Next, this invention will be explained referring to an actual example.

Actual Example.

12 mm thick poly urethane interconnecting foam (void ratio of 90 %, average pore diameter of 0.5 mm) was put into the bottom part of the gypsum mold shown in Figure 2, and the casting sludge with the following composition was poured in from the top.

Component	Weight parts
Mullite ($3Al_2O_3$ X $2SiO_2$)	86
SiC	13
Poly vinyl alcohol	0.5
CELUNA D-735 (dispersion agent made by Chukyo Yushi K.K.)	0.5
Water	60

After leaving it for 30 minutes, the forming mold was separated, and it was put into an

oven and heated at 500 °C for 60 minutes, and the poly urethane interconnecting foam part was decomposed and removed, and thereafter, it was sintered by heating at 1200 °C for 60 minutes in air. Thus, the ceramic porous body (void ratio of 80 %, average pore diameter of 0.3 mm) with a thickness of 10 mm was obtained.

The ceramic porous body obtained like this was put in the forming mold shown in Figure 4, and the molten metal of an aluminum alloy (Si: 12 %, Fe: 0.8 %, Cu: 0.8 %, Mg: 0.7 %, balance of Al) was poured between the inner mold and the outer mold, and it was compressed by a press under a pressure of 1,000 kg/ cm^2, and it was taken out after cooling, and the piston like the one shown in Figure 1 was obtained. The thickness of the metal layer of the outer circumference of the crown part was 0.5 mm.

Thermal property tests and heat insulation tests were conducted for the piston that was obtained.

In the heat insulation test, the crown part of piston was inserted into a furnace, and it was set in the way that the parts other than the crown part were outside the furnace, and a thermocouple was installed on the surface of the crown inside the furnace and on the reverse side of the crown part that was outside the furnace, and the above mentioned surface temperature and the reverse side surface temperature were measured while increasing the temperature inside the furnace, and the temperature difference (ΔT) was obtained.

Also, for comparison, the same test was conducted for an aluminum alloy piston that was cathodic oxidation treated.

The results of the above mentioned tests are shown in Table 1 and Table 2.

Table 1

	Heat conductivity(w / m X k)	Thermal diffusivity (cm^2 / S)	Specific heat (J / g X k)
Actual Example	91	0.400	0.855
Existing Example	140	0.648	0.815

Table 2

Temperature in furnace (°C)	ΔT (°C)	
	Actual Example	Existing Example
200	96	76
300	115	101
400	135	125
500	184	158
600	207	185

As is clear from the data listed in Table 1 and Table 2, in the case when the composite material of this invention is used for the crown part of the piston, the temperature of the piston ring groove part becomes lower than that in the existing model due to the low heat conductivity and excellent heat insulating ability, therefore, the wear resistance of the piston ring groove part can be improved.

[Effect of the Invention]

When the composite material of this invention is used for the crown part of the piston, due to its excellent heat insulating ability and excellent heat resistance, the engine output can be improved, and the wear resistance of the piston ring groove part can be improved.

4. Simple Explanation of the Figures

Figure 1 is the cross section that indicates an example where the composite material of this invention was used for the piston. Figures 2 ~ 4 are explanatory figures that show a production method for the above mentioned piston in the order of the process.

[Main Marks on the Figures]

(1) : Piston main body

(2) : Crown part

(10): Porous ceramic body

(11) : Interconnecting pores

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{Insert figures}

Figure 1

1: Piston main body

2: Crown part

10 : Porous ceramic body

Figure 3

10: Porous ceramic body

11: Pores

Figure 4

10: Porous ceramic body

35: Molten metal